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(54) [Title] Melt field control method

(57) [Claims]

[Claim 1] A melt field control method wherein an object is melted by forming a control layer filled with granular material adjacent to the surface of the said object being melted and flowing electricity into the aforementioned object.

[Claim 2] The melt field control method disclosed in claim 1 characterized in that the aforementioned object is contaminated soil.

[Claim 3] The melt field control method disclosed in claim 1 or 2 characterized in that the aforementioned object is soil that contains solids.

[Claim 4] The melt field control method disclosed in any of claims 1 through 3 characterized in that the melting point of the aforementioned control layer is higher than that of the aforementioned object, and
the particle size of the aforementioned granular material is greater than that of the aforementioned soil.

[Claim 5] The melt field control method disclosed in claim 4 characterized in that the aforementioned granular material has a grain size that leaves 80% or more residue in a 1.18 mm mesh sieve.

[Claim 6] The melt field control method disclosed in any of claims 1 through 5 characterized in that the aforementioned granular material is one of either silica sand, crushed rock, or ceramic.

[Claim 7] The melt field control method disclosed in any of claims 1 through 6 characterized in that an outer container is disposed on the opposite side of the aforementioned control layer from the aforementioned object.

[Claim 8] The melt field control method disclosed in claim 7 characterized in that the aforementioned outer container possesses shielding properties with respect to gas and water.

[Detailed Description]

[0001]

[Pertinent Technical Field] This invention pertains to a melt field control method, and specifically pertains to a melt field control method, which, when melt-processing contaminants by flowing electricity into a contaminant, such as solids buried in soil or contaminated soil, etc. is able to control unnecessary spreading of the melt field by the contaminants and can address off-gassing that accompanies melting of the contaminants.

[0002]

[Prior Art] An environmental problem has recently intensified at abandoned factory and laboratory sites in which soil is contaminated by the effluents of hazardous chemical reagents and residues containing hazardous substances that were used at these facilities. Therefore, technologies have become necessary

to restore this contaminated soil to its original condition or to remove the contaminants. A variety of research is underway for this purpose.

[0003] Amidst this, in-situ vitrification (ISV) technology is being developed as one of these countermeasures, which cleans contaminated soil by melting and vitrifying the soil itself at the original site at which those contaminants exist in the soil. Therefore, Figure 3 shows the melt processing system procedure, which vitrifies the contaminated soil itself using this ISV technology.

[0004] As shown in Figure 3(A), first, an off-gas hood H is installed on the perimeter soil S1 in which contaminated soil S2 is present, which is the original site to be melt processed, so as to entirely cover the top of the contaminated soil S2, which is the object of remediation, and overlap onto clean soil. Furthermore, melt electrodes ME1 and ME2 are inserted into the clean topsoil. Next, a conductive low-resistance path R is laid between the melt electrodes ME1 and ME2 to facilitate the initial flow of electrical current.

[0005] The melt electrodes are each rod electrodes made, e.g., from graphite to withstand high temperatures. In addition, ductwork is connected to the off-gas hood H to exhaust gas produced during the remediation process from the contaminated soil being cleaned to an off-gas treatment system.

[0006] Electrical power supplied from a generator or the power grid is flowed to the melt electrodes ME1 and ME2. At this time, since there is a conductive low-resistance path R, Joule heat is generated along this low-resistance path R, which Joule heat melts the soil on and surrounding the low-resistance path, turning it to a magma form.

[0007] As shown in Figure 3(B), since the electrical resistance of the melted portion is vastly decreased by this electrical current and the soil is melted, soil adjacent to the low-resistance path R is sequentially melted by the electrical power supplied from the melt electrodes ME1 and ME2, forming a melt zone MG. The melt zone MG sequentially expands from the top of the contaminated soil S2 toward its lower portion. The interior takes a magma form, where a thermal convection phenomenon occurs.

[0008] Therefore, as electrical power continues to be supplied to the melt electrodes ME1 and ME2, the melt zone MG spreads further downward and/or sideways. The melt electrodes ME1 and ME2 are further inserted downward according to this expansion. Insertion of the melt electrodes at this time may be such that the electrodes sink downward under their own weight according to the melting of the soil, or such that they are inserted separately grasping the melted condition of the soil.

[0009] Thus, once melting has been completed to the extent to that all the contaminated soil S2 requiring melt processing has been included, the supply of electricity to the melt electrodes ME1 and ME2 is stopped. As shown in Figure 3(C), since the volume of the melt zone MG, in which the contaminated soil S2 has been melted, is decreased by 25 to 50%, from the viewpoint of its original state, the area of subsidence can be reburied with new soil S3.

[0010] Since treatment of one batch of the contaminated soil S2 to be cleaned is thus completed, the off-gas hood H can be moved to the next batch process.

[0011] With the ISV technology described above, decontamination processing can be accomplished in-situ using a portable facility. This facilitates the in-situ treatment of even contaminants for which excavating the contaminated soil would be difficult. For contaminant-inclusive contaminated soil that can be excavated, the soil can be placed in a special container and melt processed inside that container, and then reburied in clean soil, making it unnecessary to transport it to a separate location, such as a disposal site, etc.

[0012] In addition, by utilizing ISV technology to vitrify contaminated soil, e.g., heavy metals and radioactive substances, etc. in the soil can be melted and solidified sealed inside a vitrified mass, while insoluble hazardous organic substances, such as dioxins, etc., can be pyrolyzed and rendered harmless by the high 1,600 to 2,000°C temperatures when the soil is melted.

[0013] Furthermore, besides contaminated soil, it is also possible to batch process solids, such as incinerated ash, fireproof bricks, or drums, etc., and flammables, such as plastics, etc., in-situ. Moreover, vitrifying these solids together with soil not only enables melt processing to be performed that vastly reduces the volume of the soil, but also has the characteristic of being able to maintain long-term stability through vitrification.

[0014] On the other hand, while the example of in-situ melt processing of contaminants has been given in the descriptions until now, ISV technology can also be employed to perform batch melt processing in cases in which a hole is excavated appropriate to the contaminants or the aforesaid solids, etc. to be melt processed and the contaminants or solids, etc. are buried in that hole. This case is a similar situation to the case shown in Figure 3(A), except that the contaminated soil S2 is replaced from contaminants or solids, etc. that have been transported from another location. Melt processing of these contaminants or solids, etc. is performed according to the melt processing procedure shown in Figure 3.

[0015]

[Problems to be Solved] However, when ISV technology is used to melt process contaminated soil or soil in which solids, etc. have been buried, the contaminants that are the object of processing are melted by the electrical power flowing to the inserted melt electrodes ME1 and ME2, as discussed above, which melt zone gradually melts the surrounding contaminated soil. When this occurs, the resistance of the contaminated soil itself is decreased by the melting of the contaminated soil, making it even easier for electrical current to flow in the newly melted zone and generating greater Joule heat. This phenomenon is sequentially transmitted to the soil touching the melt zone MG, expanding the melt zone MG downward and/or sideways and spreading the melt field.

[0016] However, while Joule heat is gradually generated by the electrical power that continues to be supplied between the melt electrodes ME1 and ME2, this generated heat not only melts the contaminated soil itself, but also

melts the surrounding soil S1 that encloses the contaminated soil and is in contact with said contaminated soil S2. Therefore, the melt zone MG exceeds the field in which the current path formed by the melt electrodes ME1 and ME2 is formed, expanding and growing into the laterally adjacent surrounding soil S1.

[0017] Even though the contaminated soil S2 touches the surrounding soil S1 on a vertical plane, as shown in Figure 3, the melt zone MG that is formed exceeds the boundaries in which the contaminated soil S2 exists, melting adjacent portions of the surrounding soil S1. The shape of the melt zone MG bulges laterally in the middle, e.g., like a persimmon.

[0018] From the viewpoint of the essential purpose of melt processing, this melting of the bulging zone in the middle is unnecessary. Because of this, the consumption of excess melting energy to melt the bulging zone in the middle and supplying wasted energy become problematic when contaminated soil S2 is melt processed.

[0019] Therefore, the purpose of this invention is to provide a melt field control method that is able to control the spread of melting so that melt processing is limited to the contaminants when melt processing contaminates using ISV technology, and thereby to process the gas produced and released from the melt zone and improve energy efficiency.

[0020]

[Means of Solution] In order to solve the aforementioned problems, this invention constitutes a melt field control method wherein an object is melted by forming a control layer filled with granular material adjacent to the surface of the said object being melted and flowing electricity into the aforementioned object.

[0021] It is also characterized in that the aforementioned object is contaminated soil or soil that contains solids, the melting point of the aforementioned control layer is higher than that of the aforementioned object, and the particle size of the aforementioned granular material is greater than that of the aforementioned soil, wherein the aforementioned granular material has a grain size that leaves 80% or more residue in a 1.18 mm mesh sieve.

Furthermore, the aforementioned granular material is one of either silica sand, crushed rock, or ceramic.

[0022] In addition, an outer container is disposed on the opposite side of the aforementioned control layer from the aforementioned object and the aforementioned outer container possesses shielding properties with respect to gas and water.

[0023]

[Embodiment] An embodiment of the melt field control method of this invention will be explained below, which vitrifies a contaminant together with soil by melt processing.

[0024] In conventional soil vitrification, in which melt processing is performed using ISV technology, as shown in Figure 3,

As shown in Figure 3, in past contaminated soil vitrification, which performed melt processing using ISV technology, exploiting the characteristic of performing melt processing and vitrification in-situ, with the contaminated soil in its undisturbed state, melt electrodes were directly inserted into the contaminated soil to be melt processed in the surrounding soil, and electricity was supplied to them, or when the contaminated soil or solids, etc. to be melt processed were transported from another location, buried in a suitable hole excavated in the ground, and melt processed, melt electrodes were inserted into the contaminated soil to be melt processed, and electricity was supplied to them.

[0025] Since circumstances in past melt processing methods were such that, even though the contaminated soil was melted by electrical power to form a melt zone, said zone was in direct contact with the surround soil in the process of melting the contaminated soil, the melt zone would consequently expand into the surrounding soil, exceeding the field of the contaminated soil that was the object of processing.

[0026] Consequently, when the contaminated soil that is the object of melt processing is melted in the melt processing of contaminated soil using ISV technology according to this embodiment, a control layer that is difficult

to melt at the temperature of the melt zone formed by melting the contaminated soil is disposed so that it is not in direct contact with the surrounding soil. This control layer is formed with a filling of granular material, so that the spread of the melt zone is limited to within the field surrounded by the control layer during the process of melting the contaminated soil with the electrical power supplied from the melt electrodes.

[0027] Furthermore, since this control layer is disposed, said control layer is made with gas permeability so that gas produced in the process of melting the contaminated soil is not sealed inside the melt zone. Therefore, formation of the control layer used in the melt field control method of this embodiment constitutes filling in a granular material. For example, silica sand, crushed rock, or ceramic powder is used as this granular material.

[0028] The contaminated soil melt field control method using ISV technology according to this embodiment will be explained, referring to Figure 1 and Figure 2.

[0029] An example will be described as a embodiment of the melt field control method of this invention in which contaminated soil or solids, etc. that are the object of processing are placed in a suitable hole excavated in the ground, and then this processing object is melted. Contaminated soil is given as a typical example of the processing object here.

[0030] First, as shown in Figure 1, a hole is excavated in the surrounding soil S1 that is larger than the volume of the contaminated soil S2 scheduled for melt processing. Melt processing can be performed in the ground in the melt field control method of this embodiment, and the control layer is formed in direct contact with the surrounding soil S1. Figure 1 shows a situation in which an external container 1 matching the shape of the hole has been provided to ease excavation of said hole. Steel sheet piles, etc. can be listed as examples of the material forming the outer container 1.

[0031] in addition, this outer container 1 does not necessarily have to be installed when executing this melt field control method, but in cases in which there is a possibility that water will infiltrate into the melt process at the work site, e.g., if the excavated hole is near the water table, the

hole may be permeated by rainwater, or the soil is damp, etc., an outer container 1 with a bottom plate may be installed. By thus preventing the infiltration of water in the entire hole, melting energy will not be consumed vaporizing water, further increasing energy efficiency.

[0032] Additionally, when an outer container 1 is installed, steel sheet piles or the like may be driven in to enclose the planned scope of excavation for the hole, after which, the earth may be removed from the area enclosed by the sheet piles, etc. In this case, the buried sheet piles, etc. can be used directly as the outer container 1. Once a hole of the planned size has thus been excavated, or after an outer container 1 has been installed in the hole, silica sand SS can be packed in to a uniform depth as granular material over the entire bottom surface of said hole, forming a control layer on the hole bottom.

[0033] Silica sand is used here as an example of granular material, but crushed rock is also acceptable, or a powder made from ceramic material is also acceptable. However, it is critical that the size of the particles of the granular material be greater than the particles of the soil being melted, such that silica sand is selected with a particle size such that separation using a 1.18 mm mesh sieve leaves 80% or more residue.

[0034] Thus selecting the granular material fill is so that there is a difference between the particle size of the soil that is the object of processing and the particle size of the granular material filled as the control layer when granular material is filled in as a control layer, whereby the melting temperature of the soil that is the object of processing can be higher than the temperature at which the control layer melts. For example, this difference melting points can be 100°C or greater, preferably 200°C or greater. Since silica sand and crushed rock have high melting points and excellent adiabatic properties, and moreover, will not produce low-melting point materials, they can prevent molten material from advancing into the control layer.

[0035] In addition, if 20% or more of the granular material passes through a 1.18 mm mesh sieve, once the granular material has been filled in,

the gas-permeability of the control layer will not be able to be adequately maintained.

[0036] Next, in order to form a space to accommodate the contaminated soil S2, partition plates 2 are erected, keeping a gap from the wall of the hole, in which the control layer will be formed. Partition plates 2 are used here to facilitate the formation of a distinct wall of silica sand SS, since said space naturally cannot be formed simply be piling up silica sand SS. The space between the outer container 1 and the partition plates 2 is then filled to the top of the hole with silica sand SS that has the aforesaid granular composition.

[0037] Since it was possible to preserve a space to accommodate the contaminated soil to be processed, the contaminated soil S2 is packed into said space and an off-gas hood H is disposed completely covering the upper opening of the outer container 1. Next, the melt electrodes ME1 and ME2 are inserted and a conductive resistance path R is installed between the melt electrodes ME1 and ME2.

[0038] Further, since partition plates 2 have been used for the convenience of preserving a space to accommodate the contaminated soil S2, it is pulled out before melt processing the contaminated soil S2. Consequently, the partition plates 2 may be made from any material, such as wood or steel plate, etc. as long as it is sufficiently hard. If it is a material with a lower melting point and high gas-permeability than silica sand SS, it may be left in the ground. If melt processing is performed with partition plates with poor gas-permeability remaining in place, either multiple holes are preformed in the surfaces of the partition plates or the partition plates which are porous themselves can be used.

[0039] In the above, the contaminated soil S2 is prepared for melt processing by enclosing the side surfaces and bottom surfaces of the contaminated soil S2 in a control layer of silica sand SS. At this point, the flow of electricity to the melt electrodes ME1 and ME2 is started, after which the procedure for melt processing the contaminated soil S2 is the same as the melt processing procedure shown in Figure 3.

[0040] Formation of the melt zone in a case in which the partition plates 2 have been removed is shown in Figure 2, wherein the partition plates 2 have been removed and are not shown. The contaminated soil S2 is sequentially melted from the top by conventional melt processing, forming a melt zone, as shown in Figure 2. When the contaminated soil S2 comes in contact with the surrounding soil S1 as in the conventional melt processing shown in Figure 3, the touching surrounding soil S1 is melted by the heat of the melt zone MG that is formed in the process of melt processing the contaminated soil S2, but since a control layer of silica sand SS is disposed surrounding the contaminated soil S2 in the melt processing of this embodiment, the heat of the molten mass is shielded by the control layer in the process of melt processing the contaminated soil S2, causing the melt zone MG to be formed in the field enclosed by said control layer. Even if some of the magma-like molten mass infiltrates between the granular material at the interface with the control layer, the field in which the melt zone is naturally controlled by adjusting the thickness of the control layer ahead of time.

[0041] In addition, since the control layer is disposed surrounding the contaminated soil S2 in melt processing according to this embodiment, not only is the formation field of the melt zone MG limited by the control layer, but the flow of gas produced in the process of melt processing is no different from the case of the melt processing shown in Figure 3. The condition during melt processing according to this embodiment is shown in Figure 2.

[0042] Off-gases a and b are produced from the melt zone MG by decomposition, vaporization, and volatilization of the substances present in the contaminated soil S2 in the process of melt processing the contaminated soil S2. The off-gas a is directly released from the top surface of the melt zone MG into the off-gas hood. Meanwhile, when the melt zone MG is in direct contact with the surrounding soil S1, as in the case of past melt processing, the off-gas b is dispersed into the surrounding soil S1, but since the control layer is formed of granular material, such as silica sand SS, etc., in the melt processing of this embodiment, and is adequately gas-permeable, when the melt zone MG touches the silica sand SS, as shown in Figure 2, the off-gas b

passes through the silica sand SS and is released into the off-gas hood H as off-gas c.

[0043] Further, the off-gas b accumulates in the off-gas hood H by the chimney effect caused by the gas-permeability of the silica sand SS, whereby the off-gas b does not stay in the control layer. Therefore, even if the silica sand SS is in direct contact with the surrounding soil S1, the off-gas b can be prevented from diffusing into the surrounding soil S1.

[0044] In addition, diffusion of the off-gas into the surrounding soil S1 can be further prevented when an outer container 1 is disposed outside the control layer, assuming that the outer container 1 itself has gas-shielding properties.

[0045] Furthermore, the silica sand SS can be reused since the off-gas b does not stay in the control layer. Even if a granular material other than silica sand SS is used in the control layer, it will have the same action as described above.

[00046] An example of contaminated soil S2 as the object of processing was used in the melt field control method of the embodiment thus far described, but if the object of processing is a solid, said solid is buried in clean soil and then placed inside a control layer, and then an initial conductivity resistance path is formed in this clean soil. The procedure for melt processing this solid is the same as when melt processing contaminated soil.

[0047] Further, the melt field control method of this embodiment was applied inside a hole excavated in the ground, above, but the melt field control method of this embodiment could be applied, e.g., inside an outer container installed on top of the ground. In this case as well, the procedure for melt processing contaminated soil is the same as when it is executed in a hole excavated in the ground.

[0048]

[Effect] Since melt processing is performed on contaminated soil after it has been contained surrounded by a control layer filled with granular material in the melt field control method for contaminated soil of this invention,

spreading of the melt zone formed by melting the contaminated soil is controlled by the presence of this control layer.

[0049] In addition, the control layer surrounding the contaminated soil S2 is filled with a granular material, such as silica sand or crushed rock, etc., and the particle composition of this granular material is such that separation using a 1.18 mm mesh sieve leaves 80% or more residue. Since this kind of granular material has a high melting point and excellent adiabatic properties, and does not produce low-melting point materials, unnecessary expansion of the melt zone accompanying melting of the contaminated soil can be controlled by the control layer.

[0050] Thus, energy efficiency can be improved in melting the contaminated soil. Furthermore, the vitrified mass resulting from the contaminated soil can be kept to a minimum.

[0051] In addition, gas produce in the process of melt processing the contaminated soil will be reliably accumulated inside the off-gas hood without diffusing into the surrounding soil.

[Brief Explanation of the Figures]

[Figure 1] This is an explanatory diagram of a embodiment of the melt field control method of this invention.

[Figure 2] This is an explanatory diagram of the flow of off-gases when this embodiment is applied.

[Figure 3] This is an explanatory diagram of an example in which a past melt processing method by in-situ vitrification (ISV) technology.

[Legend]

1 … outer container

2 … partition plates

a through c … off-gases

H … off-gas hood

ME1, ME2 … melt electrodes

MG … melt zone

S1 … surrounding soil

S2 … contaminated soil

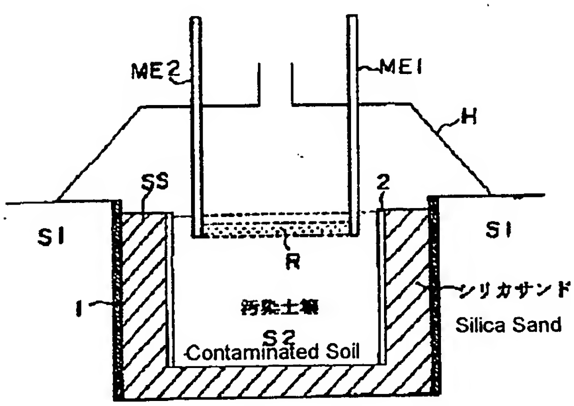
SS … silica sand

[Abstract]

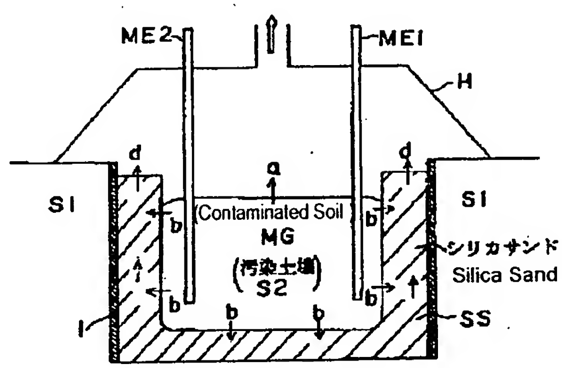
[Problem] This invention provides a melt field control method that controls the spread of the melt zone of the contaminated soil when melt processing contaminated soil, which improves energy efficiency and does not diffuse gases produce in the melting process into the surroundings.

[Means of Solution] A control layer of silica sand SS is formed inside a hole excavated in the surrounding soil S1 to accommodate contaminated soil S2. Electricity is flowed into the contaminated soil through electrodes ME1 and ME2 to form a melt zone of the contaminated soil. The silica sand of the control layer controls lateral spreading of the contaminated soil melt zone by adiabatic effect. Gas b is released as c via the gas-permeable control layer in the process of melting the contaminated soil, preventing the diffusion of off-gases into the surrounding soil.

[Fig. 1]

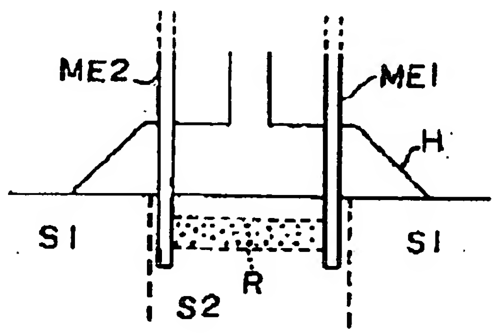


[Fig. 2]



[Fig. 3]

(A)



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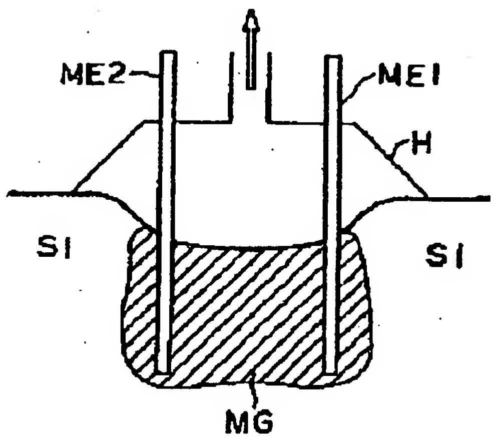

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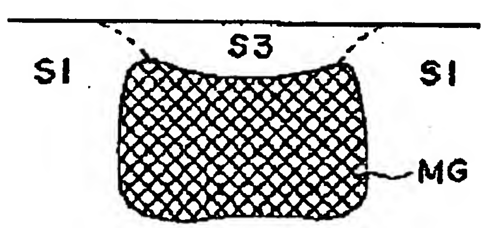

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